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Structural Adjustment and Forest Resources

The Impact of World Bank Operations

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Structural adjustment has not promoted domestic deforestation, but it has increased net imports of wood products, implying some displacement of pressure onto other countries' forest resources. Devaluations have significantly increased the exploitation of forest resources.

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Summary findings

Over two decades, the World Bank has undertaken many structural adjustment operations with governments of developing countries. During negotiations for structural adjustment loans (SALs), partner governments agree to specific policy reforms whose implementation becomes a condition for disbursement of SAL funds. Conditionality varies with local circumstances but generally supports privatization of state enterprises, liberalization of the domestic economy, and openness in international trade.

Structural adjustment operations have often been controversial because they are explicitly political. Opposition or support reflects ideological perspectives, perceptions of who gains and who loses economically from a SAL, or beliefs about its environmental and social impacts. Environmental groups express particular concern about SALs' impacts on the rate of deforestation.

Debate about adjustment and deforestation has been fueled largely by anecdotes and a few country cases based on limited time-series data. Pandey and Wheeler broaden the analysis by combining a complete record of Bank SAL operations with a 38-year socioeconomic database for 112 developing countries.

They find that adjustment has greatly affected imports, exports, consumption, and production in many forest products sectors (such as fuelwood, sawnwood, panels, pulp, and paper). Some activities have increased and some have declined, but overall the effects have balanced each other. The net impact on domestic roundwood production, the authors' proxy for forest exploitation, has been almost exactly zero. Their results suggest that growth in roundwood production is explained well by population growth, urbanization, and world demand for forest products.

Their findings suggest that adjustment has not promoted domestic deforestation, but it has increased net imports of wood products, implying some displacement of pressure onto other countries' forest resources.

They also find that devaluations have significantly increased the exploitation of forest resources.

This paper—a product of Infrastructure and Environment, Development Research Group—is part of a larger effort in the group to understand the links between economic development and environmental change. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Yasmin D'Souza, room MC2-635, telephone 202-473-1449, fax 202-522-3230, email address ydsouza@worldbank.org. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The authors may be contacted at kpandey@worldbank.org or dwheeler1@worldbank.org. April 2001. (36 pages)

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Structural Adjustment and Forest Resources: The Impact of World Bank Operations

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1. Introduction

During the past two decades, the World Bank has undertaken a large number of structural adjustment operations with the governments of developing countries. Governments often agree to structural adjustment loans (SAL's) when their resources are severely depleted by economic crises. In the Bank's view, such crises are often traceable to domestic institutional and policy problems that must be resolved before financial assistance can be useful. During negotiations for SAL's, the Bank proposes reforms that it believes would remedy the most serious problems. Negotiating governments agree to at least some of these changes, whose implementation becomes the condition for periodic disbursement of SAL funds. Although specific SAL conditions have varied with local circumstances, they have generally supported privatization of state enterprises, liberalization of the domestic economy, and promotion of openness to international trade.[1]

World Bank SAL operations are controversial because they are explicitly political: They impose policy changes that are expected to have significant impacts on economies in crisis. Opposition or support from domestic or international interest groups has depended on their ideological perspective, their perception of the distribution of economic gains and losses from a SAL, or their beliefs about its environmental and social impacts. Environmental groups have expressed particular concern about the impact of SAL's on the rate of deforestation.[2]

Despite years of controversy, the debate about adjustment and deforestation has been largely fueled by anecdotes and a few country cases based on limited time-series data. This paper attempts to broaden the analysis by combining a complete record of World Bank SAL operations with a 38-year socioeconomic database for 112 developing countries. Using this database, we

[1] For a brief description of structural adjustment loans, see World Bank (2000a). World Bank (2000b) provides a more detailed discussion of their rationale and results.
[2] See, for example, WWF International (2000) and Friends of the Earth (2000).

estimate an econometric model of trade, production and consumption of wood products that tests the impact of structural adjustment on forest resources, while controlling for other important factors. We also test the impact of several monetary, fiscal and trade policy variables that figure prominently in the Bank's policy dialogue with partner countries.

The remainder of the paper is organized as follows. In Section 2, we summarize the adjustment/deforestation debate and review the relevant literature. We develop our econometric impact model in Section 3 and report the estimation results in Section 4. Using the estimated parameters, we employ counterfactual simulations to assess the sectoral impacts of adjustment and other variables in Section 5. We extend the analysis to fiscal, monetary and trade policy variables in Section 6, and conclude the paper in Section 7.

2. Adjustment and Sustainability

Structural adjustment operations aim to increase economic welfare by reforming policies that reduce economic efficiency and distort savings/investment decisions. Adjustment often entails changes in taxes, tariffs, quotas, subsidies, price controls, public expenditures and even asset ownership. These changes are designed to promote a more open, competitive economy with fewer price distortions, better fiscal balance, and reduced public ownership of productive assets. Implementation of a SAL in a highly-distorted economy can, in principle, have widely-varying impacts on output, prices and factor returns in different sectors. In the Bank's view, a successful adjustment operation should move an economy closer to its comparative advantage in international trade, and toward production in domestic sectors whose factor intensities are well-matched with undistorted domestic factor prices. Low-income economies have a comparative advantage in labor-intensive activities, as well as production that combines unskilled labor with easily-exploitable natural resources (e.g., land, minerals, forests). Focusing on the labor side, the Bank has argued that SAL's will reduce poverty by expanding long-run employment and income opportunities for poor workers and farmers.

The Bank's environmental critics counter with the argument that SAL's undermine sustainability because they promote rapid resource depletion in economies that have little capacity to protect the commons. This argument recognizes that regulation is weak in many low-income countries whose comparative advantage lies in labor- and resource-intensive production. In response, the Bank has stressed the environmental "win-win" potential of SAL's: By removing distortions and enhancing productive efficiency, structural adjustment should reduce material wastage in all productive sectors. This should compensate, at least partially, for SAL-induced expansion of sectors that are relatively labor- and resource-intensive. Moreover, if adjustment increases prosperity, it will promote greater interest in environmental protection and create more resources to finance it.

Which view is closer to the truth? Both the Bank and its critics make points that are reasonable on a priori grounds. Simultaneous movement toward greater efficiency and greater resource-intensity could yield rising or falling natural resource use, and rising income might or might not strengthen environmental protection quickly enough to counteract resource depletion. Ultimately, determining the net impact of adjustment is an empirical issue.

During the past decade, empirical research on adjustment-environment links has grown steadily more sophisticated and data-intensive. Early inquiries by Hansen (1988) and Sebastian and Alicbusan (1989) were limited to providing a conceptual framework and chronicling the World Bank's efforts to incorporate natural resource management into its adjustment programs. As Warford, et. al. (1994) note, data scarcity and the absence of previous research forced the authors of the early studies to make untested assumptions about the channels of adjustment impact.

More recently, empirical analyses have focused on country cases from a variety of social, political and economic perspectives. Social and political analyses of adjustment's impact have tended to focus on negative outcomes (e.g., International NGO Forums (1992)), while studies of economic impacts generally report ambiguous or positive outcomes (WWF, 1994; Persson,1995; Warford, 1994; Munasinghe, 1994). Reviews of such studies by Dixon (1995) and Panayotou (1996) suggest that their results often depend on geographic or sectoral coverage, differences in motivating assumptions, and depth of analysis.

In the 1990's, a number of adjustment-environment studies have focused on forest resource use and deforestation. These studies have attempted to trace the impact of structural adjustment programs on deforestation through changes in relative prices, conversion of forested lands and collection of fuelwood. In an analysis of Ghana's structural adjustment program, Barbier and Benhin (2000) find countervailing impacts for agricultural land expansion and changes in the relative prices of agricultural and timber products. Using a computable general equilibrium (CGE) model, Glomstrod and Monge (1999) examine the migration decision of Nicaraguan squatters at the agricultural forest reserve frontier. Their results suggest that adjustment-induced income and grain price changes were important determinants of forest encroachment in Nicaragua. In a CGE study for Costa Rica, Persson, et. al. (1996) find that adjustment reduced direct logging by increasing stumpage prices, but ultimately increased deforestation through induced agricultural expansion. Angelsen, et. al. (1999) empirically analyze the linkages between agricultural prices, income, resource use and technological changes and the rate of deforestation in Tanzania. They find that increases in agricultural productivity and output prices increased the conversion of forested areas to agricultural land.

Without focusing explicitly on adjustment programs, several cross-country studies have investigated the impact of policy variables and other factors on deforestation (Capistrano, 1990; Allen and Barnes, 1985; Rudel, 1989). Attention has focused particularly on trade-related variables. An econometric study by Barbier(1994) suggests that trade itself is not a major or direct cause of deforestation. Vincent (1994) and Barbier (1994) have taken a critical view of the log export bans that many countries have employed to encourage growth of value added in domestic wood processing. They find that such policies have promoted only modest expansion of domestic processing capacity and employment in Southeast Asia, while encouraging over-exploitation of forest resources by depressing domestic log prices. In a broader international study, Capistrano (1990) finds that currency devaluations have significantly increased deforestation, but that country indebtedness (measured by the debt service ratio) has not had a significant impact.

In summary, empirical research on adjustment and the environment has yielded mixed results. A number of country case studies focused on agriculture have associated adjustment with increased agricultural prices, land clearing and deforestation. On the other hand, trade-related studies have frequently found that adjustment-induced changes have reduced pressure on forest resources. In a recent synthesis, Panayotou and Hupe (1996) find that most studies are "ultimately ambiguous as to the net positive or negative environmental consequences" of adjustment. They also note that unambiguous statements about the impact of adjustment are usually based on theory rather than empirical evidence.

3. Modeling the Impact of Adjustment on Wood Products

In this analysis, we consider the impact of adjustment on production, consumption, exports and imports of forest products. At the sectoral level, we measure the impact of adjustment on five activities: roundwood, sawnwood, panels, pulp and paper. We focus particularly on roundwood production, since it provides the only direct measure of forest resource exploitation. We use the FAO measure, which incorporates both recorded volumes and estimates of unrecorded volumes.[3] We embed adjustment in a model that incorporates the exogenous effects of world demand for wood products, export prices, import prices, population, income per capita, and structural changes associated with urbanization. Our database includes annual observations for the period 1961 - 1998 for 112 developing countries. We treat structural adjustment as an "experiment" imposed on an economy whose *ex ante* behavior is captured by observations prior to the first year of a SAL. Using the remaining observations, we estimate responses to adjustment through 1998.

Our econometric model has twenty equations, covering four activities (production, consumption, exports, imports) in our five sectors. We estimate the panel using fixed effects, with GLS corrections for heteroskedasticity.[4] Our equations are fitted to logarithms of the variables, allowing us to interpret the results as elasticities. Our database is quite large, so most of our estimates reflect samples of 1,000 or more observations.

[3] The FAO estimate of unrecorded volume provides at least some control for illegal logging. The FAO defines roundwood as follows: "Wood in the rough. Wood in its natural state as felled, or otherwise harvested, with or without bark, round, split, roughly squared or other forms (e.g. roots, stumps, burls, etc.). It may also be impregnated (e.g. telegraph poles) or roughly shaped or pointed. It comprises all wood obtained from removals, i.e. the quantities removed from forests and from trees outside the forest, including wood recovered from natural, felling and logging losses during the period - calendar year or forest year. Commodities included are sawlogs and veneer logs, pulpwood, other industrial roundwood (including pitprops) and fuelwood. The statistics include recorded volumes, as well as estimated unrecorded volumes as indicated in the notes. Statistics for trade include, as well as roundwood from removals, the estimated roundwood equivalent of chips and particles, wood residues and charcoal." For details, see the FAO Website at http://www.fao.org/waicent/faostat/forestry/products.htm.

[4] A standard Hausman test indicates selection of a fixed-effects model instead of a random-effects model in this case.

The estimating equations take the following form:

$$(1)\quad \log V_{it} = \sum_{i=1}^{M} \theta_i D_{Ci} + \beta_0 + \beta_1 T_t + \beta_2 \log P_{xit} + \beta_3 \log P_{mit} + \beta_4 \log W_{xit} + \beta_5 \log P_{oit} + \beta_6 \log N_{it} + \beta_7 \log Y_{it} + \beta_8 \log U_{it}$$
$$+ \gamma_1 D_{Ait} + \gamma_2 D_{Ait} t_{Ait} + \gamma_3 D_{Ait} t_{Ait}^2 + \varepsilon_{it}$$

where, for M countries:

i,t = Subscripts for country and time, respectively.
V = Activity volume for the product (consumption, production, exports, imports)
D_c = Country dummy variables (for fixed-effects estimation)
T = General time index
P_x = Product export price
P_m = Product import price
W_x = Total world exports of the product
P_o = Price of oil
N = Country population
Y = Real income per capita
U = Urbanization (urban population/total population)
D_A = Adjustment dummy variable
t_A = Adjustment time index

The lefthand variable in each equation is the log of volume for the relevant activity and product. Righthand variables include product export and import prices, world export volume, the price of oil, population, urbanization (urban population/total population), real GNP per capita, a time trend, and two measures of adjustment. We include the price of oil because it proxies both transport costs (wood products are bulk commodities) and energy prices more generally. Urbanization proxies the structural shifts that have accompanied rural/urban migration and the expansion of cities during the past forty years. We consider two adjustment specifications: (1) A dummy variable whose value is 0 for all periods prior to the first adjustment year and 1 thereafter. This captures the average long-run impact of adjustment. (2). Interaction of the long-run adjustment dummy with linear and squared values of time indices whose value is 0 for years prior to the first adjustment and incremented by one year thereafter. (To illustrate, an adjustment that begins in 1980 has a time index whose value is 0 for 1960-79, 1 in 1980, ..., 19 in 1998; an adjustment beginning in 1992 has a time index that is 0 for 1960-91, 1 in 1992, ..., 7 in 1998). This quadratic interaction allows for a changing trend over time. For example, a SAL may have little effect on wood products during the first year but a growing impact as adjustment takes hold. At some point, this impact may begin tailing off. The quadratic adjustment will capture both effects.

4. Results

4.1 The Impact of Adjustment

Table 1 reports adjustment parameter estimates for each of the five forest products by activity (consumption, exports, imports and production). The two column sections include results for both the constant (average) impact of adjustment and interaction with a quadratic time trend (measuring time-variation of the impact). Literally interpreted, the estimates measure changes in the logarithms of volumes. These are not identical to percent changes, but they have the same order of magnitude. The following discussion of changes always refers to changes in logs, but for convenience we will simply refer to changes.

Column 1 provides an easily-interpreted summary of average effects. Impacts on production and consumption of roundwood are very close to zero and insignificant, while the impacts on exports and imports are large, almost identical in magnitude, and oppositely signed.[5] Associated changes in the four wood-processing (roundwood-consuming) sectors seem to reflect a shift toward non-distorted comparative advantage. Exports rise modestly for sawnwood (.07) and more

[5] We have also estimated the impact equations using ordinary least squares (OLS) and a standard method for systematic pruning of outliers. The results bracket our GLS estimates: OLS suggests a positive impact of adjustment on roundwood production, while outlier-pruning suggests a negative impact. We have also estimated the GLS model with heteroskedasticity on first differenced values of all variables to account for autocorrelation. The parameter point estimates are similar to the results reported here, but are generally less significant. Results are available on request.

strongly for panels (.35), both relatively labor-intensive sectors. The converse is true for the more capital-intensive sectors, pulp and paper, whose exports fall by .59 and .44, respectively.

Concurrent changes in imports and consumption both suggest contraction of demand under adjustment. Consumption falls modestly for sawnwood, panels and paper, and more sharply (-.27) for pulp. Imports of sawnwood and paper fall slightly, while pulp imports fall sharply (-.64) and panel imports increase substantially (.26). Reduced consumption is sufficient to reduce domestic production of sawnwood, panels and paper, while pulp production rises slightly because the reduction in net imports (imports - exports) offsets the decrease in consumption in that sector.

The constant-impact estimates in Table 1 measure the average change in volume from a SAL's first year to 1998. The average interval for adjusting countries is 12 years. Our quadratic trend results suggest that sector responses to adjustment are not constant, but increase or decrease at decreasing rates until they stabilize near the end of the 12-year interval. Table 2 summarizes the trend information by comparing constant-impact results with quadratic impact estimates for years 1, 6 and 12 of the adjustment period. As we would expect, the constant (average) estimates and the mid-period (6-year) quadratic estimates generally have the same sign and the same order of magnitude.

For all four wood processing sectors, the quadratic results suggest that consumption contracts throughout the adjustment period. By the twelfth year, consumption volumes for sawnwood, panels, pulp and paper have decreased by .09, .09, .32 and .11, respectively. Exports in the two capital-intensive sectors -- pulp and paper -- have contracted by .71 and .83. After an initial surge (in panels), exports also decline modestly in the two labor-intensive sectors, sawnwood and panels. By the twelfth year, sawnwood exports are .13 below their initial levels while panel exports have declined by .06. Conversely, imports of sawnwood and panels have increased substantially (.14

and .38, respectively), while pulp imports have dropped very sharply (.71) and paper imports have recovered to a point near their initial level.

The net impact of these changes on domestic wood processing is strongly contractionary, except in pulp production. Sawnwood production falls by .31, as the effects of declines in consumption and exports are reinforced by an increase in imports. Despite increased exports, panel production falls by .25 as consumption decreases and imports increase. Pulp production rises modestly (.05), as sharply-declining imports slightly offset the rapid declines in consumption and exports. In the paper sector, production falls by .14 as declining consumption and sharply-declining exports are slightly reinforced by a small increase in imports.

Declining production in wood processing significantly reduces one source of demand for roundwood. Changes in the trade sector also suggest reduced pressure on forest resources. Exports provide the most striking story: Roundwood exports fall by .20 in the first year of adjustment, and the ensuing decline is so sharp that exports are 1.06 below their pre-SAL level by the twelfth year of adjustment. Changes on the import side also reduce pressure on domestic forest resources. By the twelfth year, roundwood imports exceed pre-SAL levels by .97.

To summarize, the estimated impact of adjustment on wood processing and trade in roundwood is uniformly benign from the perspective of domestic forest conservation: Wood processing activity falls, roundwood exports decline and roundwood imports increase. However, none of these changes is sufficient to reduce the use of forest resources. After twelve years of adjustment, roundwood production and consumption remain very close to their initial levels (with estimated increases of .03 and .02, respectively).

At first glance, this result appears contradictory. Why do roundwood consumption and production remain roughly constant while net demand actually declines in both the industrial and trade sectors? The answer emerges from a more detailed analysis of the roundwood sector, which includes fuelwood (charcoal as well as "wood in the rough") and industrial roundwood (inputs to wood processing such as sawlogs, veneer logs, pulpwood, wood particles and chips).

Table 3 reports the adjustment parameter estimates for these two subsectors, and Figures 1 and 2 display the quadratic impact results. Figure 1 shows that industrial roundwood production, consumption and exports decline sharply, as expected, while imports increase. However, Figure 2 tells a very different story for fuelwood production and consumption, which increase significantly. After an initial downward shock, fuelwood imports are also well ahead of their initial level by the twelfth year. Fuelwood exports decline initially, but recover by the twelfth year.

These results suggest that adjustment induces powerful and durable changes within the forest products sector.[6] The contraction in wood processing persists for at least a decade. However, overall roundwood production remains nearly constant as sectoral activity shifts away from industrial inputs toward the production and consumption of fuelwood. Part of this change may reflect a shift toward relatively crude, labor-intensive production as adjustment reveals a lack of comparative advantage in wood-processing. Changing relative prices may also lower the cost of scrap wood by inducing an expansion of labor-intensive agriculture at the forest margin.

[6] Our colleague Shanta Devarajan has suggested that our results may overestimate the impact of adjustment by excluding effects of the crisis conditions that often precipitate SAL's. Our inclusion of per-capita income and product prices captures some crisis effects, but we also recognize the potential importance of the terms of trade in this context. In separate regression experiments, we have included the terms of trade and a dummy-variable proxy for prior crisis conditions attributable to non-trade sources. We find that a decline in the terms of trade significantly lowers production of both fuelwood and industrial roundwood, while our prior crisis proxy is significantly associated with increased fuelwood production and decreased industrial roundwood production. Inclusion of these variables does reduce the estimated impact of adjustment on fuelwood and industrial roundwood, so the results in Table 1 could be interpreted as upper-bound impact estimates for adjustment. In any case, contervailing signs and magnitudes continue to suggest that the overall effect of adjustment on roundwood production (fuelwood plus industrial roundwood) is close to zero.

4.2 The Impact of Other Variables

Although we focus on adjustment, our results also provide useful information about the impact of other variables on forest resources. Our equations are in reduced-form, so the parameter estimates combine supply and demand effects. Table 4 reports full results (including adjustment effects) for the quadratic trend model.[7] In this section, we provide a brief summary of measured impacts on the consumption, production, exports and imports of wood products.

Consumption

Time trends in the consumption equations are generally small, and they are significant only in the cases of roundwood and paper. The lack of an autonomous trend suggests that the model variables provide a relatively complete explanation for changes in consumption. As expected, import price elasticities are all negative and generally significant. However, they are relatively small. Cross-effects through export prices, world export volumes and the price of oil display varying signs, magnitudes, and levels of significance. Even in the significant cases, however, they are relatively small. Both population and urbanization are critical variables in all equations, with large positive elasticities and uniformly high degrees of significance. Algebraically, the urbanization elasticity can be interpreted as the marginal responsiveness of urban population.[8] Income also enters significantly, and with the expected signs. Income elasticity is strongly positive for the four processing sectors (which produce "superior" goods) and slightly negative for roundwood (whose fuelwood subsector produces an "inferior" good).

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[7] Estimation of the constant-impact model yields nearly-identical results for the non-adjustment variables. Results are available from the authors on request.

[8] To illustrate, consider the result for roundwood consumption in Table 4. The estimated population elasticity is .55 and the urbanization elasticity is .27. Algebraically, separate effects for the two variables can be derived as follows: $.55 \log P + .27 (\log (U/P)) = .55 \log P + .27 (\log U - \log P) = .55 \log P - .27 \log P + .27 \log U = .28 \log P + .27 \log U$.

Exports

Time trend results for exports vary across equations, with significant positive growth rates for roundwood, sawnwood and pulp, and very small, marginally significant declines for panels and paper. All four wood processing sectors exhibit large, positive, highly-significant responsiveness to total world export demand. Roundwood, on the other hand, exhibits no responsiveness to this variable. All export price elasticities are negative, large and highly significant. These results suggest homogeneous product markets with highly elastic demand. Cross-price effects from import prices and oil prices vary widely across the five sectors. The population and urbanization elasticities are large, negative and significant. Our interpretation is that a growing population outbids international markets for wood products at the margin. Income effects are uniformly positive, large and significant. Higher incomes reflect deeper human resources and higher average product quality, which should expand foreign demand for local wood products.

Imports

Time trends for imports differ significantly for roundwood and wood processing. Roundwood imports display a significant, negative growth trend, while imports of all four wood products exhibit positive, significant growth. As expected, all sectors have large, negative, highly-significant elasticities with respect to import prices. Cross-effects from export prices, world exports and oil prices are mixed. In all cases, income elasticities are positive, large and significant. However, population results are quite mixed. General population elasticities are large and negative for sawnwood, panels and pulp. Urbanization has countervailing positive elasticities for sawnwood and pulp, but not for panels.

Production

Exogenous growth trends for production vary considerably and are generally not large. Autonomous growth is positive but small for roundwood (approximately 1.2% per year). Negative cross-effects from export prices reflect the strong negative impact of those prices on export demand. Cross effects from import and oil prices vary across sectors, while total world exports have consistently positive and generally significant effects. Population effects vary considerably, but urbanization effects are positive, large and almost always significant. Income also varies widely in impact, with a significantly negative but very small effect on roundwood production, strongly positive effects on panels and paper, and less significant effects on sawnwood and pulp.

4.3 Summary of Results

Roundwood production is the natural focus of this exercise, since it is our proxy for exploitation of forest resources. Our results suggest that the exogenous variables have very strong impacts on roundwood consumption, exports and imports. Remarkably, however, these effects largely neutralize one another on the production side. Income, for example, has a relatively small but significant negative impact on roundwood consumption, a larger positive impact on roundwood exports, and a large countervailing impact on imports. Net imports therefore rise while consumption is falling, and roundwood production actually falls as income increases. Similarly, import, export and oil price effects come very close to balancing one another, even though they have strong effects in the trade equations. World export demand has a positive and significant, although relatively modest, impact on roundwood production. Population and urbanization seem to have the largest impacts.

The results in Table 4 have interesting implications for the adjustment/deforestation debate. The large response elasticities for individual sectors show why partial evaluations can be very misleading in this context. Focusing only on fuelwood exports, for example, might lead to the conclusion that adjustment greatly increases deforestation. Our results suggest a fuelwood export surge of approximately 70% in the first year of adjustment. However, they also suggest a rapid decrease in industrial roundwood exports, an increase in imports, and a decline in industrial roundwood production. If viewed in isolation, these results would suggest that adjustment strongly reduces deforestation. In fact, the full results show that the combined impact of the sectoral responses is approximately neutral.

However, the results also suggest that this domestic neutrality may not be reflected in the trade sector. Table 5 displays the differences between import and export parameters in Table 1 (constant adjustment effects). Positive differences imply displacement of pressure to forest resources in other countries, while negative differences imply relaxation of external pressure. The displacement impact of adjustment is mildly negative for three of the wood processing sectors (sawnwood, panels and pulp), but large and positive for paper and even larger for roundwood itself. The overall impact would depend on relative volumes of activity in the five sectors, but the large displacement effects for paper and roundwood are certainly worth noting.

5. Simulation Experiments

To provide further perspective on the impact of SAL's, we have used the econometric results to simulate changes in forest products with and without adjustment. We produce the counterfactual by substituting median values of the righthand variables into the equations whose estimated parameters are reported in Table 4. We assume that adjustment begins in 1985, to allow for an interval long enough to capture the full estimated impact effects. We normalize the results to 100 in 1961 for clarity of interpretation. The results are displayed in Figures 3-9.

The strong impact of adjustment on wood processing is strikingly apparent in Figures 3-6, which present results for sawnwood and paper. Figure 3 tracks the simulated history of sawnwood production and consumption from 1961 to 1998. By 1984, both have grown by about 100% relative to their 1960 levels. Without adjustment rapid growth continues, generating final production and consumption volumes that are 150% and 130% greater than their 1961 levels. If the economy goes through adjustment, however, very different paths emerge. Sawnwood production returns to its 1977 level and consumption returns to the level first reached in 1979. The shifting gap in production-consumption levels is reflected in Figure 4, which traces the same story for sawnwood exports and imports.[9] In the non-adjustment story, imports continue the decline associated with a drop in income per capita during the recessionary eighties. They do not recover to their 1984 level until well into the 1990's. Exports exhibit the same trend, but recover sufficiently to exceed 1984 levels by about 14% in 1998. Under adjustment, the story again becomes very different. Exports first surge and then plummet to their 1970 level, while imports first plummet and then recover strongly.

Paper provides an even more spectacular case. Figure 6 shows that without adjustment, paper exports grow by 250% after 1984 (from around 1400 to around 3500). Under adjustment, however, paper exports rise to their 1980 level in 1997. Imports continue to increase without adjustment, while adjustment induces a return to a level typical of the late 1960's. Although the economy remains a net exporter of paper under adjustment, the trade gap is obviously much smaller than in the non-adjustment case. These shifts are reflected in the production-consumption

[9] Although the graphs display indices normalized to 100 in 1961, actual volumes for production and consumption are very similar. Differences in index levels therefore reflect differences in volumes.

graphs of Figure 5: Paper remains a fast-growing sector of the economy, but adjustment significantly slows the growth of both activities.

Figures 7, 8 and 9 illustrate the impact of adjustment on roundwood activity. Without adjustment, roundwood exports fluctuate around a mild upward trend from 1960 to 1998 (Figure 7). After three decades, they have only grown by about 20%. Imports track the domestic economy in the non-adjustment case, rising to a peak in 1975 and then falling to their 1960 levels by 1998. Again, adjustment generates a very different story. Exports plummet, imports surge, and the economy trends strongly toward status as a net roundwood importer.

Figures 8 and 9 trace adjustment's overall consequences for roundwood consumption and production. Figure 8 focuses on the period after 1980, showing that by 1998 consumption has converged with its non-adjustment level while roundwood production is slightly higher. Figure 9 tracks the simulated history of roundwood production and consumption since 1960, showing that adjustment has little effect on their relentless upward trend. By 1998, roundwood production is about 130% higher in than in 1960 regardless of adjustment.

If adjustment has had little net impact on forest resource use, what do our results suggest about the major causes of deforestation? Figures 10 - 12 use the econometric results to assess the relative impacts of income per capita, world demand, population and urbanization on roundwood production. Figure 10 shows that income change has been even less important than adjustment in this context, while Figure 11 shows that world export growth has had a modest impact. The converse is obviously true for Figure 12, which demonstrates the major impact of demographic change. With no population growth and a stable rural/urban ratio, roundwood consumption is only 20% higher in 1998 than in 1961. Production is 65% higher (with the balance exported), but this is still only half of the change when population and urbanization increase at their historical rates.

Our results therefore suggest that demographic changes have dominated the forest products story since 1960.

6. Macro-Policies and Forest Resources

The World Bank engages in constant policy dialogue with its partner countries, whether or not they are going through structural adjustment. To gain further insight into the impacts of adjustment-related policy reforms, we have also estimated a roundwood production equation that incorporates the monetary, fiscal and trade policy variables developed by Easterly (2000).[10] They include monetary indices (M2/GDP, inflation rate, real interest rate), fiscal indices (budget surplus/GDP, external debt/GDP) and trade measures (real effective exchange rate, terms of trade (export price/import price) and degree of openness (total trade/GDP)).

Theoretically, many of these variables could affect forest resource exploitation. Changes in interest or inflation rates, for example, could change rates of time preference, investment behavior and, by extension, deforestation. Similarly, governments saddled with high debt/GDP ratios might promote forest resource mining to earn foreign exchange. Environmentalist critics of the Bank's policy advice have also expressed concern about the trade sector, arguing that devaluation and trade liberalization may accelerate deforestation.[11]

Table 6 reports the trade sector results for roundwood production. We have excluded the monetary and fiscal indices from the reported results because none of these variables (including external debt) has a significant impact. Neither does our measure of openness, whose sign is negative in any case (more openness is associated with lower roundwood production). However,

[10] We exclude adjustment from this equation, since the policy variables should capture the relevant effects in adjusting countries.

[11] Our review of World Bank SAL's has not identified any cases in which conditionality included devaluation. However, discussions of foreign exchange policy have undoubtedly figured in some of the Bank's policy dialogues with partner countries.

our result for the exchange rate supports environmentalist concerns about the impact of devaluation. The estimated exchange-rate elasticity of roundwood production is -.19, implying that each 10% depreciation of the currency induces a 2% increase in roundwood production. Major devaluations are not uncommon, so the implied impact could be quite large. The terms of trade also appear to have a significant effect, with an estimated elasticity of .18. This suggests that each 10% improvement in the terms of trade increases roundwood production by about 2%. Since movements in this variable are largely beyond anyone's control, however, the only significant policy variable seems to be the exchange rate.

7. Summary and Conclusions

In this paper, we have used a new panel dataset to estimate the impact of World Bank structural adjustment loans on forest resources in developing countries. We find that SAL's affect many forest product sectors, but in divergent directions. Fuelwood production rises, for example, but industrial roundwood production falls as adjustment reduces activity in wood processing. The overall impact appears to be neutral for domestic forest resources, although an increase in net roundwood imports suggests that some pressure is displaced to other countries. Among sources of domestic deforestation, our results suggest that population growth and urbanization have dominated other factors by a large margin. We have analyzed the effects of monetary, fiscal and trade policy variables that figure prominently in the World Bank's policy dialogue with partner countries. Among these variables, only the terms of trade and the exchange rate have significant impacts on forest resource use.

In conclusion, we offer a few additional thoughts about the significance of our results for the adjustment/deforestation debate. First, the variety of sectoral responses to adjustment implies that analyses based on a few sectors may be quite misleading. In a similar vein, selective trade or industry measures are likely to have unexpected, and in some cases perverse, impacts on forest resources in adjusting economies. Direct promotion of appropriate regulatory institutions and policies seems much more likely to control the pressure on forest resources. Finally, our results suggest that income growth has actually reduced the pressure on forest resources, while population growth and urbanization have greatly increased it. By implication, policies that promote fertility reduction and rural development may be the most effective indirect measures for reducing deforestation.

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Table 1: Estimated Sectoral Impacts of Adjustment[a]

Sector / Activity	**Constant Effect**	**Quadratic Effect**		
Roundwood		Const.	Linear	Quadratic
production	0.0034	-0.0185	0.0080**	-0.0003
exports	-0.5615**	-0.0771	-0.1289**	0.0039**
consumption	0.0062	-0.0631**	0.0207**	-0.0012**
imports	0.5657**	0.0960	0.1374**	-0.0054**
Sawnwood				
production	-0.0976**	-0.0034	-0.0127	-0.0011**
exports	0.0724	-0.1768	0.1497**	-0.0122**
consumption	-0.0253	-0.0560	0.0313**	-0.0028**
imports	-0.0277	-0.3737**	0.1111**	-0.0057**
Panels				
production	-0.1285**	-0.1016	-0.0025	-0.0009
exports	0.3458**	0.1846	0.0749**	-0.0079**
consumption	-0.0741	-0.1211	0.0122	-0.0008
imports	0.2551**	0.2532**	-0.018	0.0024
Pulp				
production	0.0551	-0.2434**	0.1023**	-0.0065**
exports	-0.5945**	-0.6568**	0.0266	-0.0026
consumption	-0.2707**	-0.3251**	0.0182	-0.0015
imports	-0.6373**	-0.3549**	-0.0527	0.0019
Paper				
production	-0.0401	-0.0729	0.0209**	-0.0022**
exports	-0.4398**	0.0053	-0.1056**	0.0030
consumption	-0.003	-0.0478	0.0132	-0.0016**
imports	-0.0104	-0.0829	0.0194	-0.0009

[a] ** denotes significance at .05 or higher.

Table 2: Period Effects of Adjustment

	Constant	Quadratic		
		Period		
Roundwood		1	6	12
production	0.003	-0.011	0.019	0.034
exports	-0.562	-0.202	-0.710	-1.064
consumption	0.006	-0.044	0.019	0.017
imports	0.566	0.228	0.726	0.967
Sawnwood				
production	-0.098	-0.017	-0.118	-0.308
exports	0.072	-0.039	0.284	-0.130
consumption	-0.025	-0.028	0.029	-0.090
imports	-0.028	-0.268	0.089	0.144
Panels				
production	-0.129	-0.105	-0.147	-0.254
exports	0.346	0.252	0.349	-0.056
consumption	-0.074	-0.110	-0.077	-0.090
imports	0.255	0.238	0.231	0.380
Pulp				
production	0.055	-0.148	0.138	0.055
exports	-0.594	-0.633	-0.591	-0.712
consumption	-0.271	-0.308	-0.269	-0.318
imports	-0.637	-0.406	-0.603	-0.715
Paper				
production	-0.040	-0.054	-0.026	-0.137
exports	-0.440	-0.097	-0.521	-0.833
consumption	-0.003	-0.036	-0.024	-0.113
imports	-0.010	-0.064	0.001	0.020

Table 3: Estimated Sectoral Impacts of Adjustment[a]

Sector / Activity	**Constant Effect**	**Quadratic Effect**		
FuelWood				
production	0.0507**	0.0079	0.01067**	-0.00023
exports	0.4470**	0.7398**	-0.1356	0.01024
consumption	0.0440**	0.0231	0.0106**	-0.00020
imports	-0.0394	-1.0427**	0.2996**	-0.01213**
Ind. Roundwood				
production	-0.0817**	-0.0293	-0.0025	-0.00178**
exports	-0.5937**	-0.1064	-0.1351**	0.00390**
consumption	-0.0475	-0.0382	0.0159	-0.00250**
imports	0.5548**	0.1305	0.1527**	-0.00760**

[a] ** denotes significance at .05 or higher.

Table 4: Estimation Results[a]

	Roundwood				Sawnwood			
	Prod	**Cons**	**Exp**	**Imp**	**Prod**	**Cons**	**Exp**	**Imp**
Time	0.01185**	0.00429**	0.0348**	-0.0311**	0.002356	0.0014	0.0288**	0.0539**
	(0.001)	(0.002)	(0.008)	(0.012)	(0.003)	(0.003)	(0.010)	(0.011)
ln Export Price	-0.0043	-0.0102	-0.6876**	-0.1588**	-0.0064	0.0606**	-0.5785**	0.1274**
	(0.004)	(0.007)	(0.046)	(0.046)	(0.011)	(0.014)	(0.052)	(0.038)
ln Import Price	0.00337	-0.0254**	0.2511**	-0.4358**	0.0191**	-0.0702**	0.0138	-0.8401**
	(0.005)	(0.010)	(0.048)	(0.055)	(0.009)	(0.013)	(0.034)	(0.046)
ln World Exports	0.0655**	0.08475**	-0.0089	0.18128	0.1002	0.1096	0.6369**	-0.2284
	(0.018)	(0.031)	(0.134)	(0.144)	(0.073)	(0.100)	(0.285)	(0.314)
ln Oil Price	0.0325**	0.04151**	-0.1616**	0.1152**	0.06559**	0.0566**	-0.0479	0.0262
	(0.005)	(0.009)	(0.035)	(0.049)	(0.008)	(0.012)	(0.027)	(0.039)
ln Population	0.2709**	0.5476**	-0.3903	0.1137	0.07894	0.2346**	-0.5884	-0.583
	(0.064)	(0.105)	(0.258)	(0.492)	(0.116)	(0.103)	(0.306)	(0.305)
ln GNP P.C.	-0.0325**	-0.0440**	0.2764**	0.9347**	0.01037	0.2887**	0.5509**	1.363**
	(0.010)	(0.017)	(0.056)	(0.083)	(0.019)	(0.022)	(0.062)	(0.061)
ln Urbanization	0.15108**	0.2738**	-1.5703**	2.2438**	1.0436**	0.8685**	-0.3901**	0.4734**
	(0.030)	(0.057)	(0.297)	(0.293)	(0.072)	(0.063)	(0.187)	(0.239)
Adjust. Const.	-.01846	-0.0631**	-0.0771	0.0960	-0.0034	-0.0560	-0.1768	-0.3737**
	(0.015)	(0.029)	(0.171)	(0.164)	(0.042)	(0.048)	(0.144)	(0.159)
Adjust. Trend	0.0080**	0.0208**	-0.1289**	0.1374**	-0.0127	0.0313**	0.1497**	0.1111**
	(0.004)	(0.007)	(0.026)	(0.046)	(0.008)	(0.010)	(0.038)	(0.040)
Adjust Trend Sq.	-0.0003	-0.0012**	0.0039**	-0.0054	-0.0011**	-0.0028**	-0.0122**	-0.0057**
	(0.0002)	(0.000)	(0.001)	(0.003)	(0.000)	(0.001)	(0.002)	(0.002)
Observations	928	982	1014	1014	1349	1474	1476	1476

[a] ** denotes significance at .05 or higher.

Table 4: Estimation Results (cont'd)

	Panels				Pulp			
	Prod	Cons	Exp	Imp	Prod	Cons	Exp	Imp
Time	-0.0243**	0.0066	-0.012	0.1478**	0.03957**	0.01068	0.2019**	0.1045**
	(0.007)	(0.007)	(0.014)	(0.013)	(0.012)	(0.011)	(0.034)	(0.021)
ln Export Price	-0.1391**	0.03613**	-0.8196**	-0.0761**	-0.1553**	-0.01454	-0.7811**	-0.1024
	(0.027)	(0.016)	(0.054)	(0.033)	(0.045)	(0.046)	(0.121)	(0.063)
ln Import Price	-0.0612**	-0.1984**	-0.1476**	-1.1636**	0.0048	-0.0920	0.1462	-0.3318**
	(0.026)	(0.024)	(0.047)	(0.042)	(0.027)	(0.050)	(0.097)	(0.101)
ln World Exports	0.5453**	0.2774**	0.6927**	-0.2875**	0.5249**	0.0276	1.3202**	0.3777
	(0.086)	(0.081)	(0.175)	(0.124)	(0.212)	(0.203)	(0.600)	(0.310)
ln Oil Price	0.1327**	0.06828**	0.1015**	0.0588	0.0740**	0.0153	0.1681**	0.0637
	(0.022)	(0.021)	(0.044)	(0.037)	(0.025)	(0.026)	(0.074)	(0.033)
ln Population	0.7114**	0.8445**	-0.0549	-1.6547**	-0.46925	1.4740**	-8.414**	-4.092**
	(0.246)	(0.209)	(0.494)	(0.473)	(0.469)	(0.411)	(1.145)	(0.760)
ln GNP P.C.	0.3347**	0.5901**	0.7790**	1.4006**	0.12078	0.2958**	0.5380**	0.967**
	(0.040)	(0.035)	(0.079)	(0.071)	(0.070)	(0.057)	(0.166)	(0.090)
ln Urbanization	1.3468**	0.8911**	-0.5349**	-0.8688**	0.1971	1.0583**	-0.04173	1.5389**
	(0.130)	(0.119)	(0.254)	(0.233)	(0.171)	(0.181)	(0.604)	(0.366)
Adjust. Const.	-0.1016	-0.12108	0.1846	0.2532**	-0.2434**	-0.3251**	-0.6568**	-0.3549**
	(0.076)	(0.078)	(0.139)	(0.127)	(0.089)	(0.088)	(0.196)	(0.161)
Adjust. Trend	-0.0025	0.0122	0.0750**	-0.0180	0.1023**	0.0182	0.0266	-0.0527
	(0.020)	(0.018)	(0.033)	(0.027)	(0.018)	(0.016)	(0.040)	(0.030)
Adjust Trend Sq.	-0.00085	-0.00084	-0.0079**	0.0024	-0.0065**	-0.00147	-0.0026	0.0019
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.003)	(0.001)
Observations	1154	1300	1311	1311	262	360	360	360

Table 4: Estimation Results (cont'd)

	Paper			
	Prod	Cons	Exp	Imp
Time	0.0169**	0.0177**	-0.0380	0.0604**
	(0.007)	(0.006)	(0.023)	(0.009)
ln Export Price	-0.1201**	-0.0351**	-0.8744**	0.0344
	(0.025)	(0.016)	(0.035)	(0.024)
ln Import Price	0.1358**	-0.1564**	0.8832**	-0.8375**
	(0.022)	(0.031)	(0.090)	(0.044)
ln World Exports	0.0587	0.1334	1.5122**	-0.0822
	(0.133)	(0.103)	(0.402)	(0.149)
ln Oil Price	-0.0124	-0.0237	-0.06476	0.03795
	(0.017)	(0.014)	(0.053)	(0.021)
ln Population	0.46597**	0.9531**	-0.9899**	0.8166**
	(0.154)	(0.105)	(0.393)	(0.183)
ln GNP P.C.	0.3869**	0.523**	1.1756**	0.8459**
	(0.030)	(0.021)	(0.072)	(0.032)
ln Urbanization	1.9667**	0.8014**	1.994**	-0.0114
	(0.097)	(0.092)	(0.273)	(0.148)
Adjust. Const.	-0.0729	-0.0479	0.0053	-0.0829
	(0.051)	(0.044)	(0.166)	(0.067)
Adjust. Trend	0.0209**	0.0132	-0.1056**	0.0194
	(0.011)	(0.011)	(0.043)	(0.016)
Adjust Trend Sq.	-0.0022**	-0.0016**	0.00298	-0.0009
	(0.001)	(0.001)	(0.003)	(0.000)
Observations	1095	1397	1399	1399

Table 5: Adjustment and Trade in Forest Products

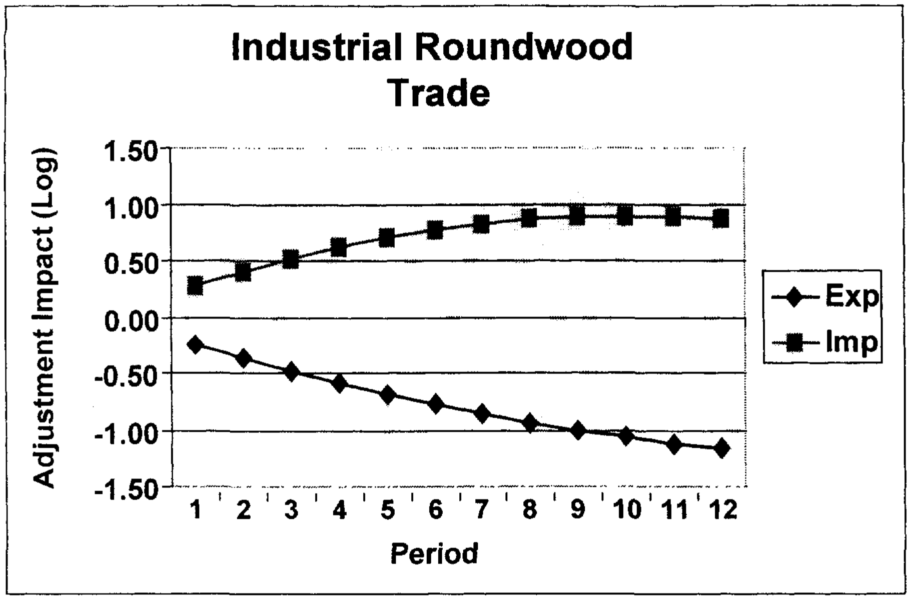
	Adjustment Impact		
Sector	Imports	Exports	Difference
Roundwood	0.566	-0.562	1.128
Sawnwood	-0.028	0.072	-0.100
Panels	0.255	0.346	-0.091
Pulp	-0.637	-0.594	-0.043
Paper	-0.010	-0.440	0.430

Table 6: Trade Policies and Roundwood Production

	Roundwood Production
Time	-0.00039
	(0.004)
ln Export Price	-0.0056
	(0.006)
ln Import Price	-0.00452
	(0.008)
ln World Exports	0.0829**
	(0.028)
ln Oil Price	0.0184**
	(0.009)
ln Population	0.7550**
	(0.164)
ln GNP P.C.	0.0172
	(0.017)
ln Urbanization	0.1484**
	(0.062)
ln Real Exch Rate	-0.1914**
	(0.041)
ln Openness	-0.0408
	(0.050)
ln Terms of Trade	0.1782**
	(0.0678)
no of obs	630

Figure 1: Impact of Adjustment on Industrial Roundwood Activities

(1a). Imports and Exports



(1b) Production and Consumption

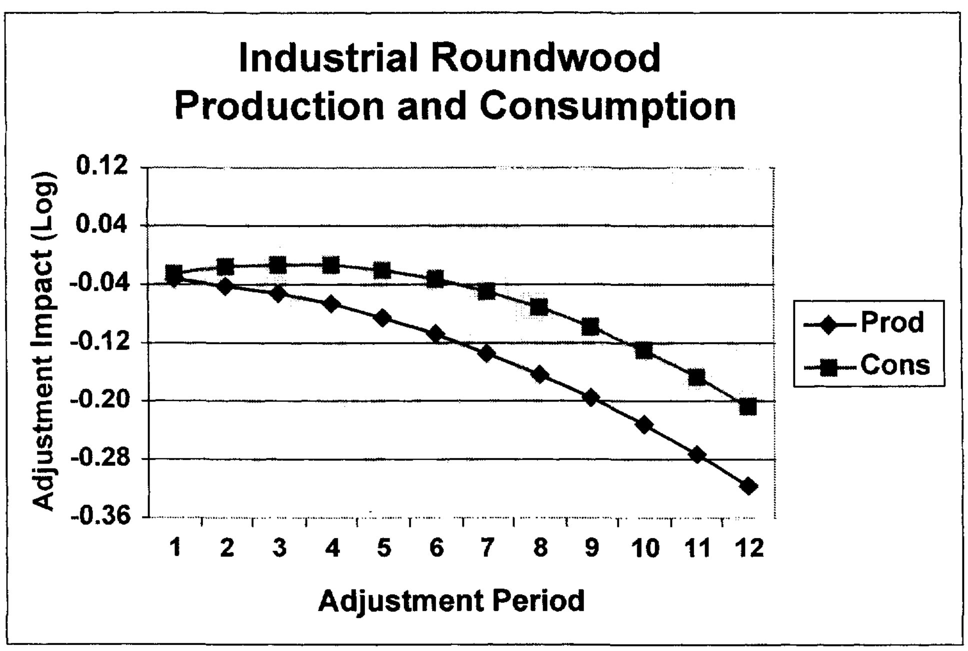
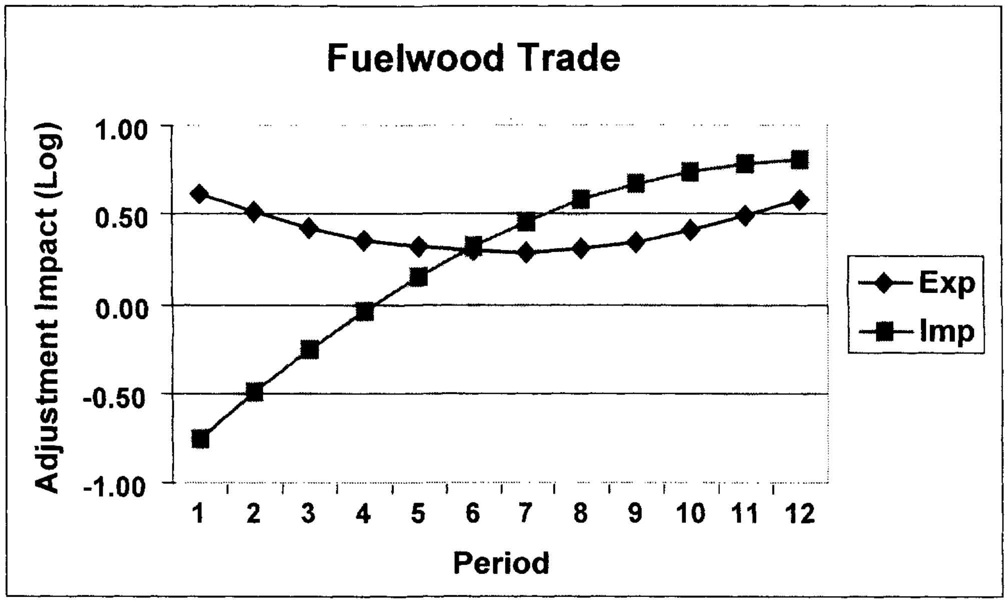


Figure 2: Impact of Adjustment on Fuelwood Activities

(2a) Imports and Exports



(2b) Production and Consumption

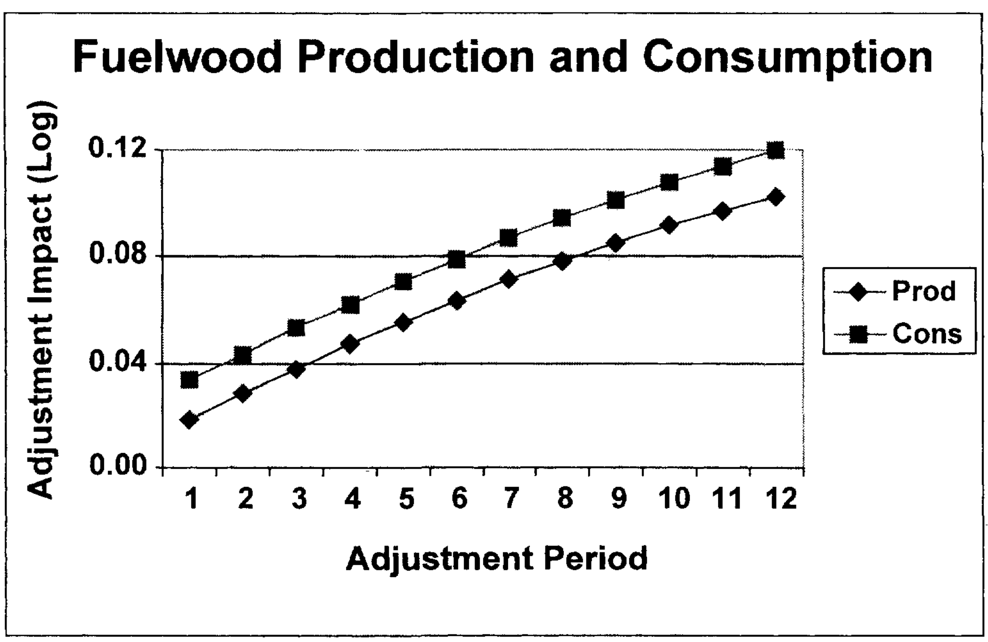


Figure 3: Adjustment and Consumption/Production of Sawnwood

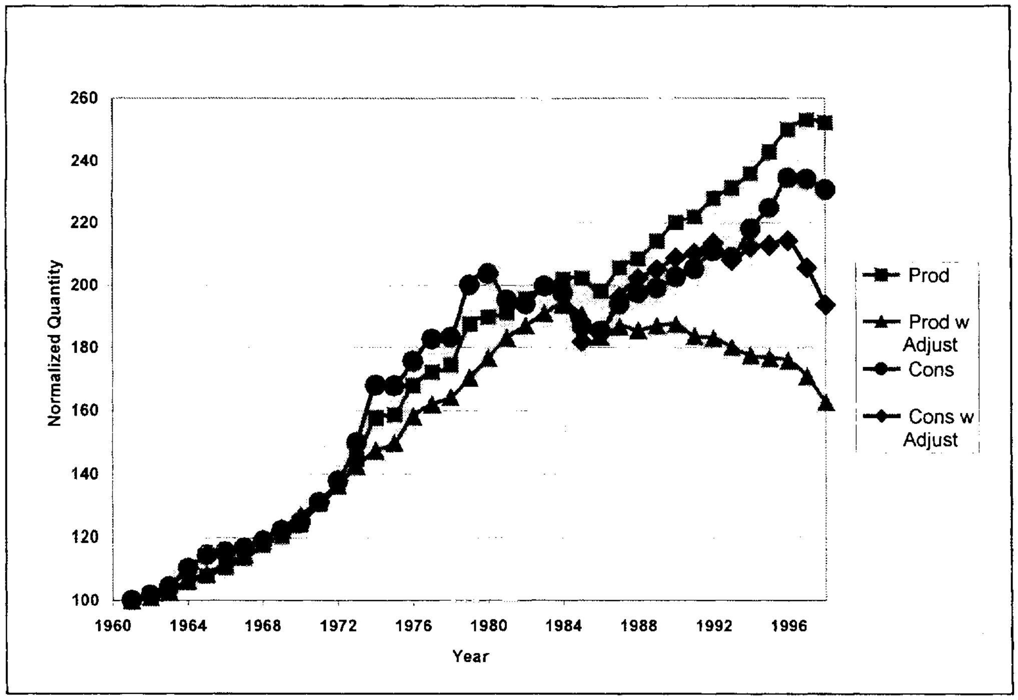


Figure 4: Adjustment and Trade in Sawnwood

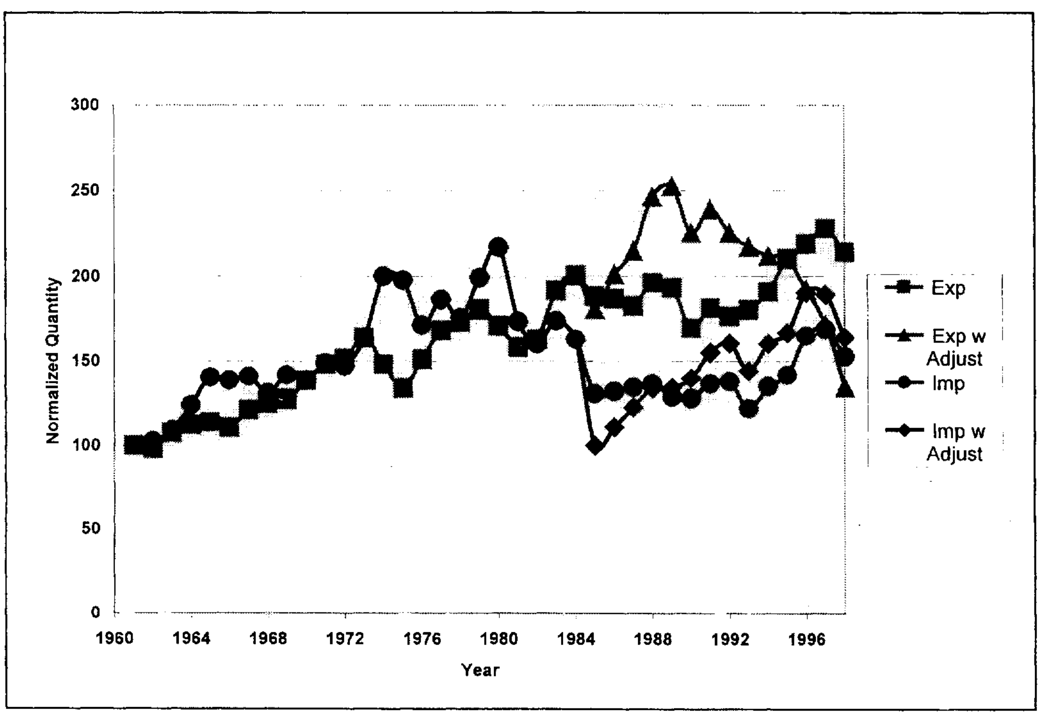


Figure 5: Adjustment and Production/Consumption of Paper

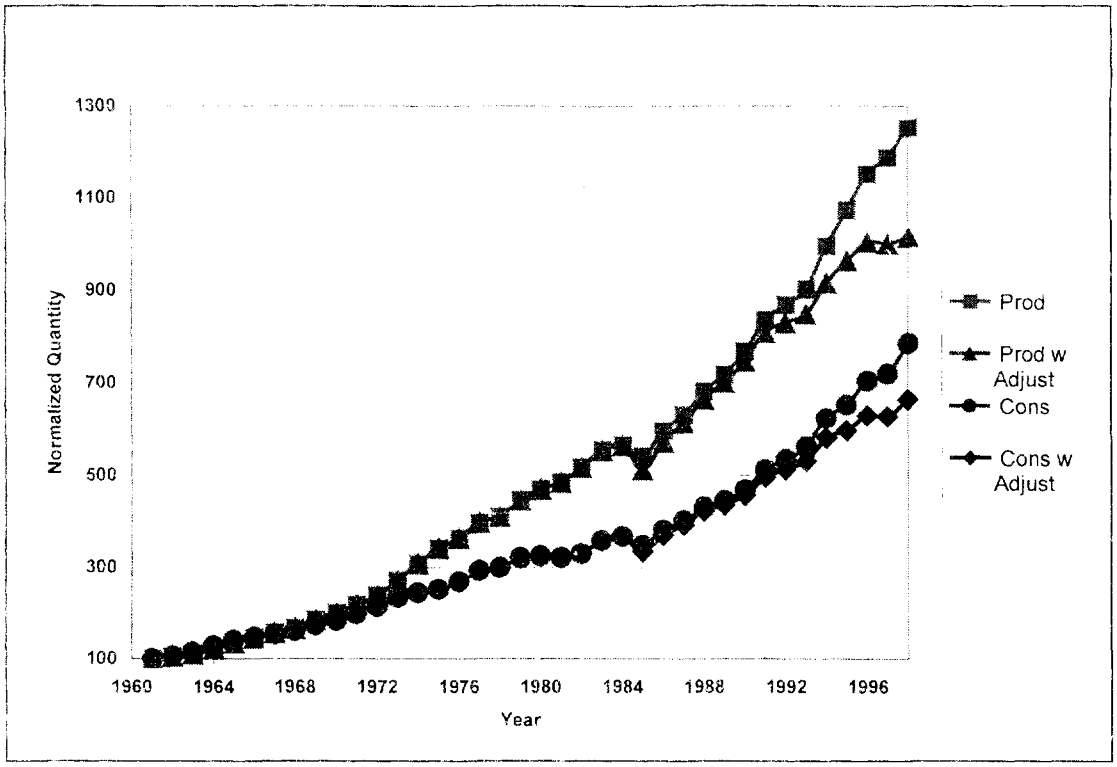


Figure 6: Adjustment and Trade in Paper

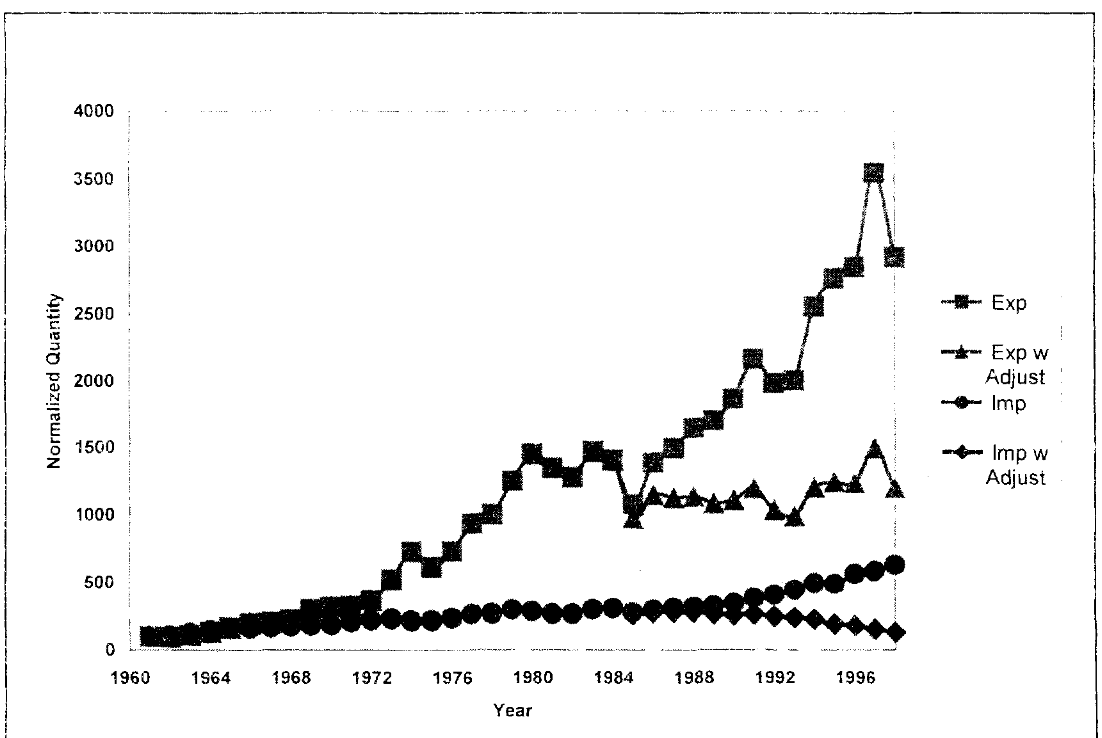


Figure 7: Adjustment and Trade in Roundwood

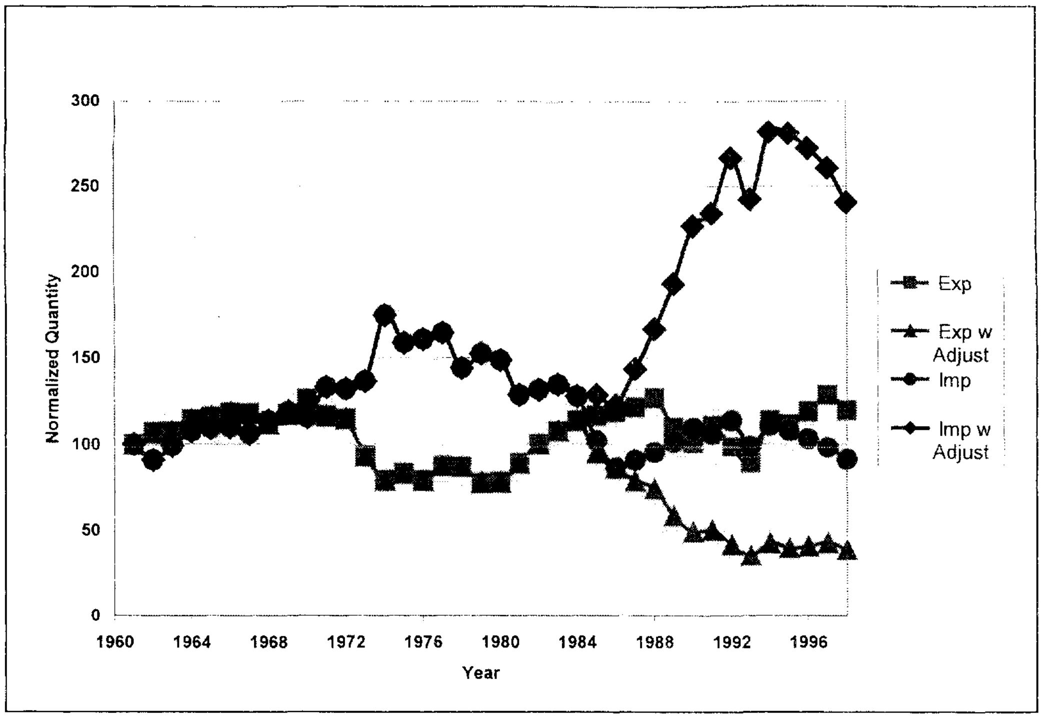


Figure 8: Adjustment and Production/Consumption of Roundwood, 1980 - 1998

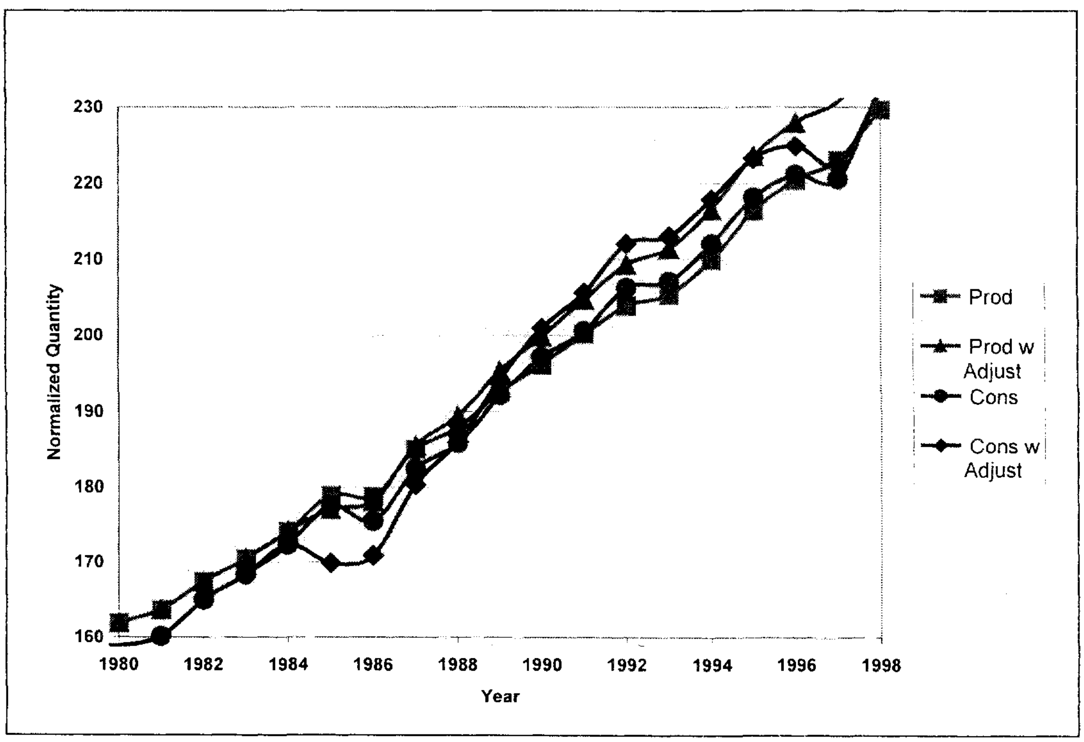


Figure 9: Adjustment and Production/Consumption of Roundwood, 1960 - 1998

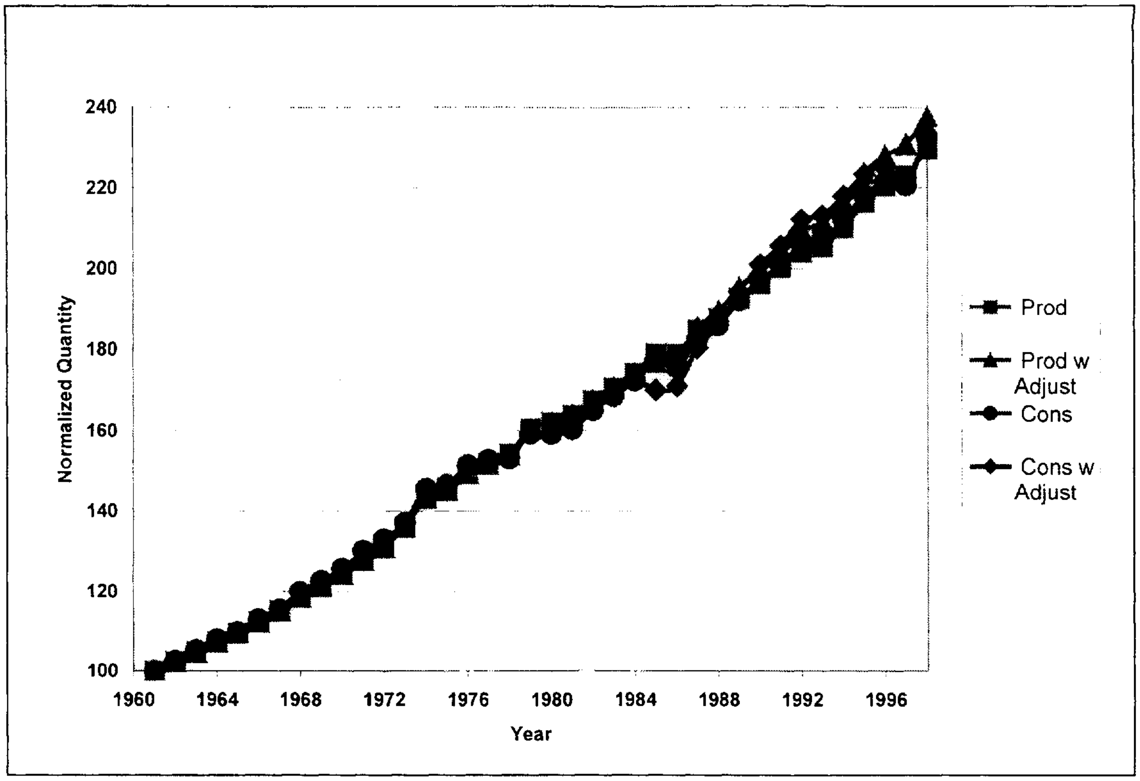


Figure 10: Impact of Income per Capita on Roundwood Production/Consumption

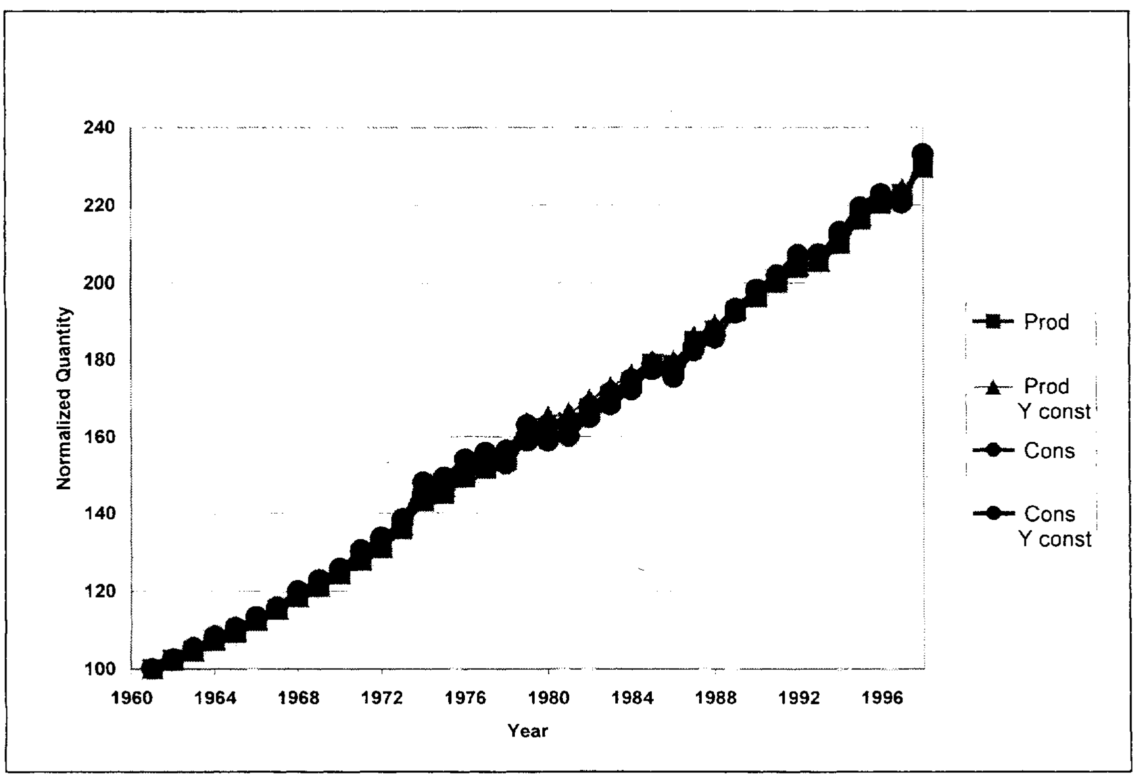


Figure 11: Impact of World Exports on Roundwood Production/Consumption

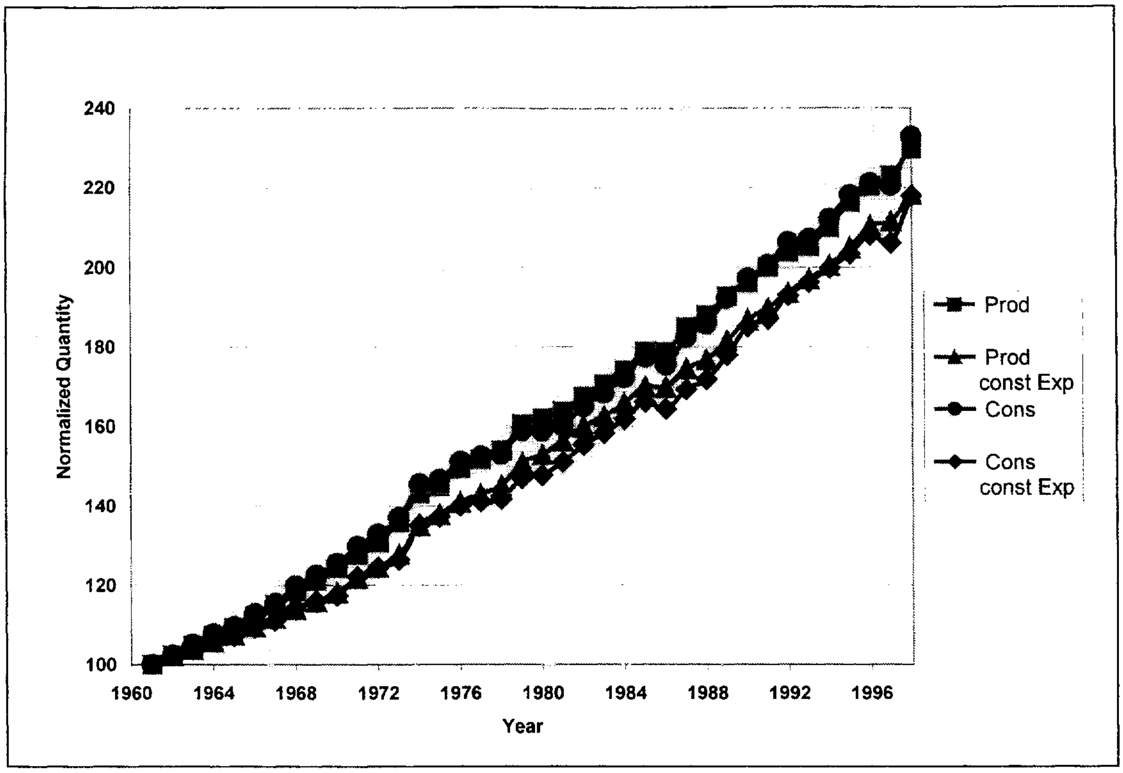
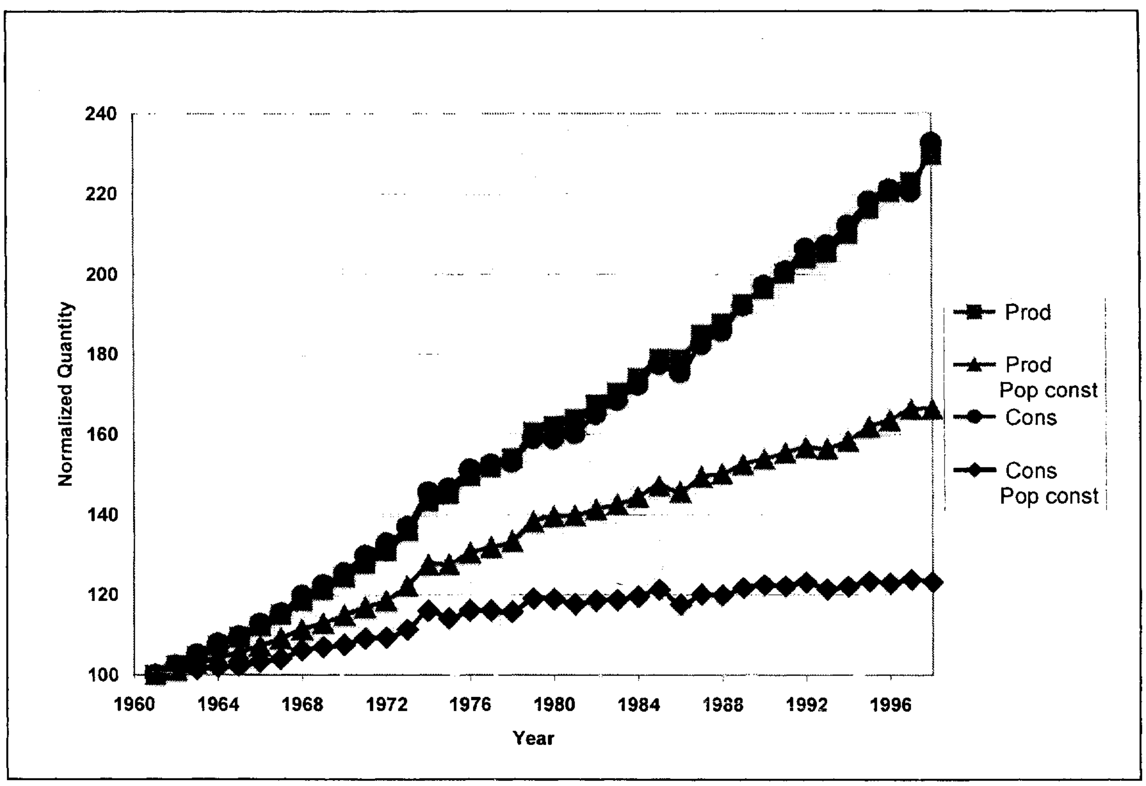


Figure 12: Impact of Population and Urbanization on Roundwood Production/Consumption



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